UNITED STATES ENVIRONMENTAL PROTECTION AGENCY
REGION III
1650 Arch Street
Philadelphia, Pennsylvania 19103-2029

Mr. Larry Lawson, Director
Division of Water Program Coordination
Virginia Department of Environmental Quality
629 Main Street
Richmond, VA 23219

Dear Mr. Lawson:

The Environmental Protection Agency (EPA) Region III is pleased to approve the Total Maximum Daily Load (TMDL) report for the primary contact use (bacteria) impairment on Muddy Run. The TMDL report was submitted to EPA for review in April 2004. The TMDL was established and submitted in accordance with Section 303(d)(1)(c) and (2) of the Clean Water Act to address an impairment of water quality as identified in Virginia's 1998 Section 303(d) list.

In accordance with Federal regulations at 40 CFR §130.7, a TMDL must comply with the following requirements: (1) designed to attain and maintain the applicable water quality standards, (2) include a total allowable loading and as appropriate, wasteload allocations (WLAs) for point sources and load allocations for nonpoint sources, (3) consider the impacts of background pollutant contributions, (4) take critical stream conditions into account (the conditions when water quality is most likely to be violated), (5) consider seasonal variations, (6) include a margin of safety (which accounts for uncertainties in the relationship between pollutant loads and instream water quality), (7) consider reasonable assurance that the TMDL can be met, and (8) be subject to public participation. The enclosure to this letter describes how the TMDL for the primary contact use impairment satisfies each of these requirements.

Following the approval of the TMDL, Virginia shall incorporate the TMDL into an appropriate Water Quality Management Plan pursuant to 40 CFR § 130.7(d)(2). As you know, all new or revised National Pollutant Discharge Elimination System permits must be consistent with the TMDL WLA pursuant to 40 CFR §122.44 (d)(1)(vii)(B). Please submit all such permits to EPA for review as per EPA's letter dated October 1, 1998.

If you have any questions or comments concerning this letter, please don't hesitate to contact Mr. Thomas Henry at (215) 814-5752.

Sincerely,

Jon M. Capacasa, Director
Water Protection Division

Enclosure

Decision Rationale

Total Maximum Daily Loads for
the Primary Contact Use (Bacteriological) Impairments on Muddy Run

I. Introduction

The Clean Water Act (CWA) requires a Total Maximum Daily Load (TMDL) be developed for those water bodies identified as impaired by a state where technology-based and other controls will not provide for attainment of water quality standards. A TMDL is a determination of the amount of a pollutant from point, nonpoint, and natural background sources, including a margin of safety (MOS), that may be discharged to a water quality-limited water body.

This document will set forth the Environmental Protection Agency's (EPA's) rationale for approving the TMDL for the primary contact use (bacteriological) impairment on Muddy Run. EPA's rationale is based on the determination that the TMDL meets the following eight regulatory conditions pursuant to 40 CFR §130.

1) The TMDL is designed to implement applicable water quality standards.
2) The TMDL includes a total allowable load as well as individual waste load allocations and load allocations.
3) The TMDL considers the impacts of background pollutant contributions.
4) The TMDL considers critical environmental conditions.
5) The TMDL considers seasonal environmental variations.
6) The TMDL includes a margin of safety.
7) There is reasonable assurance that the TMDL can be met.
8) The TMDL has been subject to public participation.

II. Background

The Muddy Run Watershed is located in Culpeper County, Virginia. Muddy Run is located within the Rappahanock River Basin. There are two impaired segment of Muddy Run. The first impairment begins at its headwaters and extends to the confluence with Apperson Creek, this is know as the Upper Muddy Run Segment. The second impairment begins a 1/4 of a mile upstream of Route 229 and extends to the mouth of Muddy Run which is the confluence with the Hazel River. The 19,000-acre watershed is rural with forested and agricultural lands making up 57 and 40 percent of the watershed respectively. Developed lands account for less than 3 percent of the total watershed area. There are three point sources in the watershed.

In response to Section 303(d) of the CWA, the Virginia Department of Environmental Quality (VADEQ) listed 5.55 miles of Muddy Run (VAN-E07R) on Virginia's 1996 Section 303(d) list as being unable to attain its primary contact use. This segment was listed on the 1998

and 2002 Section 303(d) lists as well. In 2002, the Upper Muddy Run segment was added to the Section 303(d) list as being unable to attain its primary contact use. This segment is approximately 3.12 miles in length. Additional sampling conducted as part of the TMDL indicate that the entire stream may not be attaining the primary contact use. However, the data from the other monitoring stations is limited. The decisions to list these two segments of Muddy Run were based on observed violations of the Commonwealth's bacteriological criteria. At the time of its listing, the bacteria criteria used fecal coliform as an indicator species and had an instantaneous standard 1,000 colony forming units (cfu) per 100 milliliters (ml) and geometric mean standard of 200 cfu/100ml. This decision rationale will address the TMDL for the impairment of the primary contact use.

Fecal coliform is a bacterium which can be found within the intestinal tract of all warm blooded animals. Fecal coliform in itself is not a pathogenic organism. However, fecal coliform indicates the presence of fecal wastes and the potential for the existence of other pathogenic bacteria. The higher concentrations of fecal coliform indicate the elevated likelihood of increased pathogenic organisms.

EPA encouraged the states to use e-coli and enterococci as the indicator species instead of fecal coliform. A better correlation was drawn between the concentrations of e-coli and enterococci, and the incidence of gastrointestinal illness. The Commonwealth adopted e-coli and enterococci criteria in January 2003. According to the new criteria, streams will be evaluated via the e-coli and enterococci criteria after 12 samples have been collected using these indicator species. Twelve e-coli samples were collected from Muddy Run.

As Virginia designates all of its waters for primary contact, all waters are required to meet the bacteriological standard for primary contact. Virginia's standard applied to all streams designated as primary contact for all flows. The e-coli criteria requires a geometric mean concentration of 126 cfu/100ml of water with no sample exceeding 235 cfu/100 ml of water. Unlike the new fecal coliform criteria, which allows a 10 percent violation rate, the new e-coli criteria requires the concentration of e-coli not exceed 235 cfu/ 100ml of water.

Although the TMDL and criteria require the 235 cfu/100 ml of water concentration limit not be exceeded, waters are not placed on the Section 303(d) list if their violation rate does not exceed 10 percent. Therefore, Muddy Run may be deemed as attaining its primary contact use prior to the implementation of all of the TMDL reductions. It is necessary to keep this in mind because of the reductions required to attain the instantaneous criteria for e-coli according to the model.

The TMDL submitted by Virginia is designed to determine the acceptable load of e-coli which can be delivered to the impaired water, as demonstrated by the Hydrologic Simulation Program Fortran (HSPF)[1], in order to ensure that the water quality standard is attained and

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[1]Bicknell, B.R., J.C. Imhoff, J.L. Little, and R.C. Johanson. 1993. Hydrologic Simulation Program-FORTRAN (HSPF): User's Manual for release 10.0. EPA 600/3-84-066. U.S.

maintained. HSPF is considered an appropriate model to analyze the impaired water because of its dynamic ability to simulate both watershed loading and receiving water quality over a wide range of conditions. The model was run to determine the fecal coliform loading to Muddy Run and the loads were then changed to e-coli using a conversion factor established by the Commonwealth.

The TMDL analysis allocates the application/deposition of fecal coliform to land based and instream sources. For land based sources, the HSPF model accounts for the buildup and washoff of pollutants from these areas. Buildup (accumulation) refers to all of the complex spectrum of dry-weather processes that deposit or remove (die-off) pollutants between storms.[2] Washoff is the removal of fecal coliform which occurs as a result of runoff associated with storm events. These two processes allow the HSPF model to determine the amount of fecal coliform from land based sources which is reaching the stream. Point sources and wastes deposited directly to the stream are treated as direct deposits. Wastes which are deposited directly to the stream do not need a transport mechanism.

Local rainfall and temperature data were needed to develop the model. Weather data provides the rainfall data which drives the TMDL model. Hourly weather data was obtained from the Culpeper weather station, which is located 2 miles from the watershed.

Stream flow data was not available for Muddy Run, therefore, a paired watershed approach was used. The hydrology model was calibrated to the observed flow collected at a United States Geological Survey (USGS) gage located on Battle Run. The Battle Run model was developed using weather data collected from the Piedmont Research Center. The calibration period was from March 1981 through June 1985 and validated against gage data from January 1990 through June 1993. During the calibration the model parameters were adjusted to allow the model to more accurately represent the observed data. During validation, which insures that the model is accurately representing the stream process and not just flows from the calibration period, the parameters are held constant and the model is compared to a new data set. The model replicated the observed gage data well during the calibration and validation.

The model was then transferred to the Muddy Run Watershed, the Culpeper weather data was used to drive the model for Muddy Run as it more closely represented the conditions within the watershed. The Muddy Run model was calibrated against water quality monitoring data collected from Muddy Run from 1998 through 2002. The model was then validated against water quality data collected from 1992 through 1997.

The TMDLs were modeled using fecal coliform loading rates as was done in previous TMDL efforts. The fecal coliform concentrations were then converted to E-coli concentrations using a translator equation developed by VADEQ. Significant reductions in the modeled load

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Environmental Protection Agency, Environmental Research Laboratory, Athens, GA.

[2]CH2MHILL, 2000. Fecal Coliform TMDL Development for Cedar, Hall, Byers, and Hutton Creeks Virginia,

were required in order for Muddy Run to attain the new e-coli criteria in the model. More stringent reductions were required to meet the instantaneous standard than the geometric mean.

Table 1 - Summarizes the Specific Elements of the TMDL.

Segment	Parameter	TMDL (cfu/yr)	WLA (cfu/yr)	LA (cfu/yr)	MOS
Upper Muddy Run	E-Coli	1.02E+13	0.00	1.02E+13	Implicit
Lower Muddy Run	E-Coli	3.76E+13	2.09E+10	3.76E+13	Implicit

The United States Fish and Wildlife Service has been provided with copy of this TMDL.

III. Discussion of Regulatory Conditions

EPA finds that Virginia has provided sufficient information to meet all of the eight basic requirements for establishing a primary contact (bacteriological) impairment TMDL for Muddy Run. EPA is therefore approving this TMDL. EPA's approval is outlined according to the regulatory requirements listed below.

1) The TMDL is designed to meet the applicable water quality standards.

Virginia has indicated that excessive levels of fecal coliform due to nonpoint sources (both wet weather and directly deposited nonpoint sources) have caused violations of the water quality criteria and designated uses in Muddy Run. The water quality criterion for fecal coliform was a geometric mean 200 cfu/100ml or an instantaneous standard of no more than 1,000 cfu/100ml. Two or more samples over a 30 day period are required for the geometric mean standard. Since the state rarely collects more than one sample over a thirty-day period, most of the samples were measured against the instantaneous standard. Approximately 30 percent of the samples collected from the lower Muddy Run segment violated the applicable criteria.

The Commonwealth has changed its bacteriological criteria as indicated above. The new criteria require that the fecal coliform concentration not exceed a geometric mean of 200 cfu/100ml of water for two or more samples collected over a month nor shall more than 10 percent of the total samples exceed 400 cfu/100 ml of water. The new e-coli criteria requires a geometric mean of 126 cfu\100ml of water with no sample exceeding 235 cfu/100 ml. When the data is judged against the new criteria, the violation rate increases.

The HSPF model was used to determine the fecal coliform deposition rates to the land as well as loadings to the stream from direct deposit sources. Once the existing load was determined allocations were assigned to each source category to develop a loading pattern that would allow Muddy Run to support the e-coli water quality criterion and primary contact use. The following discussion is intended to describe how controls on the loading of e-coli to Muddy Run will ensure that the criterion is attained.

The TMDL modelers determined the fecal coliform production rates within the watershed. Data used in the model was obtained from a wide array of sources, including farm practices in the area, the amount and concentration of farm animals, animal access to the stream, wildlife in the watershed, wildlife fecal production rates, landuses, weather, stream geometry, etc.. The model combined all of the data to determine the hydrology and water quality of the stream.

The lands within the watershed were categorized into specific landuses. The landuses had specific loading rates and characteristics that were defined by the modelers. Therefore, the loading rates are different in lands defined as forested versus pasture. Pasture lands support cattle and are influenced differently by stormwater runoff. Three categories of pasture were defined in the model and each had a different loading rate as they supported a different number of cattle. The amount of cattle on the land, the time cattle spent on the land, and how much waste the cattle generated impacted the loading rate.

The Muddy Run TMDL model was run using weather data collected from the Culpeper weather station. This data was used to determine the precipitation rates in the watershed which transport the on land pollutants to the streams through overland and groundwater flows. Waste that was deposited to the land or stored was subjected to a die-off rate. The longer fecal coliform stayed on the ground the greater the die-off was. Materials that were washed off the surface shortly after deposition were subjected to less die-off.

As stated above the model for Muddy Run was developed using the paired watershed approach. Since there was no gage in the Muddy Run watershed, a stream with similar landuses and geologic characteristics with observed flow data was selected to develop the hydrology model. These parameters were selected because they influence the flow of the stream. Battle Run was selected as a suitable watershed to use as the paired watershed due to its similarities with Muddy Run. The Battle Run model was calibrated to flow data collected from USGS gage #01662800 from 1981 through 1985 and validated against a second set of data from 1990 to 1993 from the same gage. During the calibration period, the hydrology components of the model were adjusted in order to have the simulated (modeled) flow accurately represent the observed flow conditions. During validation, the model was then run and compared to a new set of observed flow conditions without adjusting the model parameters. The results of this analysis showed that the model accurately reflected the observed data.

The model was then transferred to Muddy Run for water quality calibration. The water quality model was calibrated to observed data from 1998 through 2002. The water quality model was then validated to data from 1992 through 1997. Once again the model reflected the observed data reasonably well. Modeled and observed violation rates and bacteriological concentration values were compared for several of the subwatersheds. In the next step the TMDL modelers adjusted the loading rates from the various land uses and direct deposit sources to determine what reductions were required to meet the applicable water quality criteria.

2) The TMDL includes a total allowable load as well as individual waste load allocations and load allocations.

Total Allowable Loads

Virginia indicates that the total allowable loading is the sum of the loads allocated to land based precipitation driven nonpoint source areas (forest and agricultural land segments) and point sources. Activities that increase the levels of bacteria to the land surface or their availability to runoff are considered flux sources. The actual value for total loading can be found in Table 1 of this document. The total allowable load is calculated on an annual basis.

Waste Load Allocations

There are three facilities within the Lower Muddy Run watershed that are permitted to discharge e-coli into the stream. There are no point sources permitted to discharge e-coli to the Upper Muddy Run watershed. Two of the three facilities in the Lower Muddy Run are regulated under a general permit which allows them to discharge 1,000 gallons of effluent per day with an e-coli concentration of 126 cfu/100ml. The other facility is controlled by an individual permit which allows it to discharge 10,000 gallons of effluent per day with an e-coli concentration of 126 cfu/100ml. Since these facilities are not allowed to discharge e-coli above the applicable criteria they were not required to reduce their load. The WLAs for these facilities can be determined by multiplying the daily flow by the permitted concentration and 365 after the appropriate unit conversions. Table 2 lists the WLAs for these facilities.

EPA regulations require that an approvable TMDL include individual waste load allocations (WLAs) for each point source. According to 40 CFR 122.44(d)(1)(vii)(B), "Effluent limits developed to protect a narrative water quality criterion, a numeric water quality criterion, or both, are consistent with assumptions and requirements of any available WLA for the discharge prepared by the state and approved by EPA pursuant to 40 CFR 130.7." Furthermore, EPA has authority to object to the issuance of any National Pollutant Discharge Elimination System (NPDES) permit that is inconsistent with the WLAs established for that point source.

Table 2 - WLAs for the Lower Muddy Run

Facility	Permit Number	WLA (cfu/yr)
Emerald Hill Elementary School	VA0089354	1.74E+10
Private Residence	VAG406151	1.74E+09
Private Residence	VAG406092	1.74E+09

Load Allocations

According to Federal regulations at 40 CFR 130.2(g), load allocations (LAs) are best estimates of the loading, which may range from reasonably accurate estimates to gross allotments, depending on the availability of data and appropriate techniques for predicting loading. Wherever possible, natural and nonpoint source loads should be distinguished.

In order to accurately simulate landscape processes and nonpoint source loadings, VADEQ used the HSPF model to represent the impaired watershed. The HSPF model is a comprehensive modeling system for the simulation of watershed hydrology, point and nonpoint source loadings, and receiving water quality. HSPF uses precipitation data for continuous and storm event simulation to determine total loading to the impaired segments from the various landuses within the watershed. Table 3a and 3b list the LAs for the Upper and Lower segments of Muddy Run. The reductions needed to insure that the instantaneous criteria is attained at all times is extremely stringent. If the 10 percent violation rate required for a water to be placed on the Section 303(d) list was used as an endpoint the reductions for straight pipes would remain the same but all other nonpoint sources would require less of a reduction.

Table 3a - LA for Bacteria (fecal coliform) for Upper Muddy Run

Source Category	Existing Load (cfu/yr)	Proposed Load (cfu/yr)	Percent Reduction
Livestock Direct Deposit	1.75E+12	3.50E+10	98
Wildlife Direct Deposit	2.58E+13	2.58E+13	0
Straight Pipes	6.47E+12	0.0	100
Urban Residential	4.20E+14	9.24E+13	78
Cropland	1.30E+13	3.77E+12	71

Pasture	7.07E+15	7.07E+13	99
Forest	6.88E+13	6.88E+13	0

Table 3b - LA for Bacteria (fecal coliform) for Lower Muddy Run

Source Category	Existing Load (cfu/yr)	Proposed Load (cfu/yr)	Percent Reduction
Livestock Direct Deposit	1.16E+13	1.97E+11	98
Wildlife Direct Deposit	8.02E+13	8.02E+13	0
Straight Pipes	2.23E+12	0.0	100
Urban Residential	1.19E+15	1.70E+14	78
Cropland	7.37E+13	8.96E+12	71

Pasture	2.60E+16	2.31E+13	99
Loafing Lot	1.05E+14	2.31E+13	78
Forest	3.01E+14	3.01E+14	0

3) The TMDL considers the impacts of background pollution.

The TMDL considers the impact of background pollutants by considering the bacteria load from background sources like wildlife.

4) The TMDL considers critical environmental conditions.

According to EPA's regulation 40 CFR 130.7 (c)(1), TMDLs are required to take into account critical conditions for stream flow, loading, and water quality parameters. The intent of this requirement is to ensure that the water quality of Muddy Run is protected during times when it is most vulnerable.

Critical conditions are important because they describe the factors that combine to cause a violation of water quality standards and will help in identifying the actions that may have to be undertaken to meet water quality standards[3]. Critical conditions are a combination of environmental factors (e.g., flow, temperature, etc.), which have an acceptably low frequency of occurrence. In specifying critical conditions in the waterbody, an attempt is made to use a reasonable "worst-case" scenario condition. For example, stream analysis often uses a low-flow (7Q10) design condition because the ability of the waterbody to assimilate pollutants without exhibiting adverse impacts is at a minimum.

The HSPF model was run over a multi-year period to insure that it accounted for a wide range of climatic conditions. The allocations developed in the TMDL will therefore insure that the criteria is attained over a wide range of environmental conditions including wet and dry

[3]EPA memorandum regarding EPA Actions to Support High Quality TMDLs from Robert H. Wayland III, Director, Office of Wetlands, Oceans, and Watersheds to the Regional Management Division Directors, August 9, 1999.

weather conditions.

5) The TMDL considers seasonal environmental variations.

Seasonal variations involve changes in stream flow and loadings as a result of hydrologic and climatological patterns. In the continental United States, seasonally high flows normally occur in early spring from snow melt and spring rain, while seasonally low flows typically occur during the warmer summer and early fall drought periods.

Bacteria loadings also change during the year based on crop cycles, waste application rates, and cattle access patterns. Consistent with our discussion regarding critical conditions, the HSPF model and TMDL analysis effectively considered seasonal environmental variations through the use of observed weather data over an extended period of time and by modifying waste application rates, crop cycles, and livestock practices.

6) The TMDL includes a margin of safety.

This requirement is intended to add a level of safety to the modeling process to account for any uncertainty. The MOS may be implicit, built into the modeling process by using conservative modeling assumptions, or explicit, taken as a percentage of the WLA, LA, or TMDL. Virginia included an implicit MOS in the TMDL through the use of conservative modeling assumptions in the determination of bacteria loadings and production.

7) There is a reasonable assurance that the TMDL can be met.

EPA requires that there be a reasonable assurance that the TMDLs can be implemented. WLAs will be implemented through the NPDES permit process. According to 40 CFR 122.44(d)(1)(vii)(B), the effluent limitations for an NPDES permit must be consistent with the assumptions and requirements of any available WLA for the discharge prepared by the state and approved by EPA. Furthermore, EPA has authority to object to issuance of an NPDES permit that is inconsistent with WLAs established for that point source.

Nonpoint source controls to achieve LAs can be implemented through a number of existing programs such as Section 319 of the CWA, commonly referred to as the Nonpoint Source Program.

8) The TMDL has been subject to public participation.

Three public meetings were held during the development of the TMDL. All of the meetings were held at the Emerald Hill Elementary School in Culpeper, Virginia. The meetings were held on April 1, 2003, September 16, 2003 and March 9, 2004. The meetings were attended by 13, 6, and 11 individuals respectively. All of the meetings were announced in the Virginia Register and opened to a thirty-day comment period. No written comments were received in relation to the TMDL.